CARLETON UNIVERSITY

Department of Mechanical & Aerospace Engineering

Course Outline - MECH 4604 - A, Fall 2016

Finite Element Methods

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Office hours: By appointment

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Schedule: 2 classes per week (1.5 h each)

Beginning Week 4 we will meet in the computer lab, ME3290, for hands-on instruction with ANSYS during the scheduled Tuesday class. (Date to be confirmed)

Please ensure your computer account in Mackenzie Building 3290 works before the lab starts. If not, please contact Mr. Neil McFadyen in the Department of Mechanical and Aerospace Engineering.

Course Learning Objectives

At the end of this course you will be able to:

- formulate finite element problems using the Direct Method, Minimum Total Potential Energy Method and the Method of Weighted Residuals.
- formulate the stiffness (conductance) matrix for simple one-dimensional linear and quadratic elements; beam elements; and frame elements.
- assemble element matrices into the governing system of equations, apply boundary conditions and solve.
- formulate the stiffness matrix for two-dimensional linear triangle and quadrilateral elements, including numerical integration techniques.
- perform basic structural and heat transfer analyses using Ansys Mechanical finite element software.

Also see Topics Covered in Lectures below for more details.

Course Materials

<u>(1) Textbook</u>

FINITE ELEMENT ANALYSIS, Theory and Application with ANSYS, Fourth Edition, Saeed Moaveni, Prentice-Hall Inc., 2008, ISBN 978-0-13-189080-8.

Recommended. This book is available in the Bookstore of Carleton University.

(2) ANSYS tutorials

ANSYS Tutorial Release 14, Kent Lawrence, SDC Publications, 2012, ISBN 978-1-58503-761-2.

Required. This book is available in the Bookstore of Carleton University.

Assessment

ANSYS Assignments	20%
ANSYS Exam	20%
Final Exam (FEM Theory)	60%

Note: Final exam is for evaluation purposes only and will not be returned to students.

cuLearn

Various materials related to the course, including lecture notes, are posted on the cuLearn website for the course. Additional materials may be posted throughout the term.

Note:

Topics Covered in Lectures (theory)

Corresponding chapter of the course textbook (Moaveni) is given for each section.

Chapter 1 Introduction to FEM

Introduction to finite element method (FEM) concepts; basic steps in FEM for solid mechanics problems, heat transfer problems and fluid flow problems.

Chapter 2 Formulations of FEM (Moeveni Chapter 1)

Direct formulation; minimum total potential energy formulation and weighted residual formulation (collocation method, subdomain method, Galerkin method and least-squares method).

Chapter 3 Trusses (Moaveni Chapter 3)

FEM formulation of truss problems. Transformation of boundary conditions.

Chapter 4 Axial Members, Beams and Frames (Moaveni Chapter 4)

FEM formulation of axial members, beams and frames.

Chapter 5 One-Dimensional Elements (Moaveni Chapter 5; ANSYS applications in Chapter 6)

Foundation for analysis of one-dimensional problems by introducing one-dimensional linear, quadratic, and cubic elements; concepts of one-dimensional elements and shape functions and their properties; global, local and natural coordinates; one-dimensional integrals: Gauss Legendre Quadrature.

Chapter 6 Two-Dimensional Elements (Moaveni Chapter 7; heat transfer and stress applications in Chapter 9 and 10, respectively)

Introduction to two-dimensional linear and higher order elements; rectangular element, quadratic quadrilateral element, linear triangular element, quadratic triangular element, axisymmetric element and isoparametric element; two-dimensional integrals: Gauss-Legendre Quadrature.

You may need special arrangements to meet your academic obligations during the term.

For an accommodation request the processes are as follows:

Pregnancy obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website http://www2.carleton.ca/equity/accommodation/academic/students/

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Students with disabilities requiring academic accommodations in this course must register with the Paul Menton Centre for Students with Disabilities (PMC) for a formal evaluation of disability-related needs. Documented disabilities could include but are not limited to mobility/physical impairments, specific Learning Disabilities (LD), psychiatric/psychological disabilities, sensory disabilities, Attention Deficit Hyperactivity Disorder (ADHD), and chronic medical conditions. Registered PMC students are required to contact the PMC, 613-520-6608, every term to ensure that I receive your Letter of Accommodation, no later than two weeks before the first assignment is due or the first in-class test/midterm requiring accommodations. If you only require accommodations for your formally scheduled exam(s) in this course, please submit your request for accommodations to PMC by the last official day to withdraw from classes in each term. For more details visit the PMC website:
http://www2.carleton.ca/pmc/